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Summary implementation of kmlab.ko kernal module:

First the module creates a directory kmlab and a file within this new directory called status. From there it initializes the linked list that will be used to save the process ID and the Central Processing Unit duration information. After that it labels the status file such that it can be opened with the cat command through registering it with a major number and creating an appropriate class. It then initializes the timer that will wake up every 5 seconds. Finally, it initializes the work queue. Once everything is initialized, and when a user application writes to the status file, the module saves the data into the linked list and the work queue and timer work together to update the linked list every five seconds. When a user application requests to read from the status file, the module will load all the data in the linked list in the proper format and save it into a buffer for it to be sent to the user. I should also mention that to avoid the race condition of the linked list being updated at the same time a process data is being added, the kernel module implements a static spinlock to avoid this error. With the work queue and updating the list. Once the user application process has exceeded it time, it is automatically removed from the linked list. Once the kernel module is removed, the exit function removes all the respective files, directories, lists, classes, timers, and work queues that were created when the module was loaded.

Screenshot of compiling module and user application without errors:


```
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ make
rm -f userapp *~ *.ko *.o *.mod.c Module.symvers modules.order
make -C /lib/modules/5.15.0-88-generic/build M=/home/doug/lab4/cpts-360-lab-4-DouglasTakada modules
make[1]: Entering directory '/usr/src/linux-headers-5.15.0-88-generic'
  CC [M]  /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.o
  MODPOST /home/doug/lab4/cpts-360-lab-4-DouglasTakada/Module.symvers
  CC [M]  /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.mod.o
  LD [M]  /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.ko
  BTF [M] /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.ko
Skipping BTF generation for /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.15.0-88-generic'
gcc -o userapp userapp.c
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$
```

Screenshot of output from /proc/kmlab/status for one process case:


```
  make[1]: Leaving directory '/usr/src/linux-headers-5.15.0-88-generic'
  gcc -o userapp userapp.c
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ sudo insmod kmlab.ko
  [sudo] password for doug:
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ ./userapp 10 &
  [1] 3093
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ ls /proc/kmlab/status
  /proc/kmlab/status
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
  [1]+  Done                    ./userapp 10
  cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
  cat: /proc/kmlab/status: Device or resource busy
```

Screenshot of output from /proc/kmlab/status for two process case:

```
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ ./userapp 10 &
[1] 3245
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ ./userapp 15 &
[2] 3249
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
Process 3245: CPU Time 1904000000
Process 3249: CPU Time 0
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
[1]-  Done                    ./userapp 10
Process 3245: CPU Time 6316000000
Process 3249: CPU Time 2832000000
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
Process 3249: CPU Time 6904000000
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
Process 3249: CPU Time 6904000000
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
[2]+  Done                    ./userapp 15
Process 3249: CPU Time 10512000000
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ cat /proc/kmlab/status
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$
```

Screenshot of output from /proc/kmlab/status for kmlab_test shell script:

```
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$ bash kmlab_test.sh
rm -f userapp *~ *.ko *.o *.mod.c Module.symvers modules.order
make -C /lib/modules/5.15.0-88-generic/build M=/home/doug/lab4/cpts-360-lab-4-DouglasTakada modules
make[1]: Entering directory '/usr/src/linux-headers-5.15.0-88-generic'
  CC [M]  /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.o
  MODPOST /home/doug/lab4/cpts-360-lab-4-DouglasTakada/Module.symvers
  CC [M]  /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.mod.o
  LD [M]  /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.ko
  BTF [M] /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.ko
Skipping BTF generation for /home/doug/lab4/cpts-360-lab-4-DouglasTakada/kmlab.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.15.0-88-generic'
gcc -o userapp userapp.c
Process 3790: CPU Time 4808000000
Process 3791: CPU Time 4724000000
cat: /proc/kmlab/status: Device or resource busy
doug@doug-VirtualBox:~/lab4/cpts-360-lab-4-DouglasTakada$
```